**Field Force (F) and Surface Force (F_p) in PPC Law of Gravity**

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**Abstract**

This work introduces two fundamental gravitational forces derived from the behavior of gravitational pressure: the Field Force and the Surface Force. The Field Force arises when gravitational pressure varies across space, producing acceleration through pressure gradients within the gravitational field. It represents how differences in local pressure guide the motion of matter and influence the shape of spacetime. The Surface Force, in contrast, emerges when gravitational pressure acts across a defined area, generating a compressive or expansive effect on physical boundaries or layers of matter. Together, these two forces describe how gravitational pressure distributes itself throughout space and how it interacts with surfaces, providing a clear physical mechanism that links pressure to curvature and gravitational behavior.

# Force Expressions $F$ and $F_p$ in the PPC Law of Gravity

A central contribution of the Pressure–Curvature (PPC) Law of Gravity is the recognition of **two distinct gravitational forces** that arise directly from gravitational pressure:

1. **Field Force** — generated by **pressure gradients**
2. **Surface Force** — generated by **pressure acting on an area**

Both forces originate from the same foundational identity:

$$P_g = E_d = \rho c^2.$$

This identity states that gravitational pressure is the mechanical form of energy density. Once $P_g$ exists, forces naturally arise from its variation (gradient) and from its action on surfaces.

# 1. Field Force: $F = \nabla P_g$

## 1.1 Definition

The first and primary force in the PPC Law is the **field force**, defined as:

$$\boxed{F = \nabla P_g}$$

where $P_g$ is the gravitational pressure field.

This force emerges when gravitational pressure is **not uniform in space**. A region of space with a pressure gradient produces acceleration toward regions of lower pressure.

## 1.2 Relation to Energy Density

Since

$$P_g = E_d,$$

we also have:

$$F = \nabla E_d.$$

Thus, gravitational force is fundamentally generated by **gradients in energy density**.

This is consistent with classical intuition: bodies move toward regions where energy density (and therefore pressure) is lower.

## 1.3 Physical Meaning

The field force represents:

- how spacetime “pushes” objects via pressure variation,
- how curvature emerges from unequal distribution of energy density,
- the mechanism behind gravitational acceleration.

In curved regions:

- a high pressure gradient corresponds to strong curvature,
- a low gradient corresponds to weak curvature.

## 1.4 Role in Curvature Formation

Einstein's field equations show:

$$G_{\mu\nu} \propto T_{\mu\nu}.$$

Since pressure is part of $T_{\mu\nu}$, the gradient $\nabla P_g$ affects:

- the bending of geodesics
- the tidal forces
- the strength of gravitational wells

Thus, curvature is shaped by **how pressure changes**, not just by how much pressure exists.

# 2. Surface Force: $F_p = P_g A$

## 2.1 Definition

The second force of the PPC Law is the **surface pressure force**:

$$\boxed{F_p = P_g A}$$

where

- $A$ is a physical or geometric area exposed to gravitational pressure.
- $P_g = \rho c^2$ is the gravitational pressure.

This is the relativistic analog of the Newtonian concept of pressure acting over a surface.

## 2.2 Physical Meaning

This force describes:

- how pressure **compresses or expands** an object,
- how spacetime pressure acts on **boundaries**,
- how pressure contributes to curvature in systems with finite surfaces.

Examples:

- stellar surface layers
- internal regions of neutron stars
- shells inside dense matter
- horizons near black holes
- any region of spacetime with definable area elements

## 2.3 Connection to Energy Density

Because

$$P_g = E_d,$$

the surface force becomes:

$$F_p = E_d A.$$

This shows:

- the larger the energy density,
- the greater the pressure,
- the larger the force acting on any area.

This force contributes to **structural support**, **hydrostatic balance**, and **local curvature**.

# 3. The Relationship Between $F$ and $F_p$

## 3.1 Complementary Roles

**[Origin,Meaning and Role of the Field Force (F) and Surface Force (F_p)]**

| Force | Origin |
| --- | --- |
| $F = \nabla P_g$ | spatial change in pressure |
| $F_p = P_g A$ | pressure acting on area |

| Meaning | Role |
| --- | --- |
| field acceleration | global curvature |
| surface compression or expansion | local curvature |

Together, these forces provide the complete mechanical description of how gravitational pressure shapes curvature.

## 3.2 Why PPC Requires Both Forces

Einstein's GR describes how curvature affects motion but not **what physically causes curvature**.

PPC provides the missing mechanism:

- $F = \nabla P_g$ creates differential curvature.
- $F_p = P_g A$ creates local curvature stresses.

Together they map **pressure → curvature → motion**.

# 4. Unified Interpretation

Because

$$P_g = E_d,$$

pressure forces are **energy-density forces**.

Thus:

- Gravity arises from the distribution of energy density.
- Curvature is the geometric effect of these forces.
- Motion follows the pressure-shaped geometry.

This completes the PPC causal chain:

$$\text{Mass} \rightarrow E_d = \rho c^2 \rightarrow P_g \rightarrow \{F = \nabla P_g \, , \, F_p = P_{gA} \} \rightarrow \text{Curvature} \rightarrow \text{Geodesic Motion}$$